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as of 27-Oct-2017

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Final Report for Period Beginning 01-Sep-2016 and Ending 31-Aug-2017
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Begin Performance Period: 01-Sep-2016 **End Performance Period:** 31-Aug-2017
Report Term: 0-Other

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STEM Degrees: 0 **STEM Participants:** 8

Major Goals: The major goal of this project is provide the research tools necessary to train the next generation of scientists and engineers for successful and productive careers in tribology and related fields. Tribology is an exciting research area that plays an important role in today's world, particularly due to the demand for more energy efficient and longer lasting mechanical systems. However, the researchers who will make major breakthroughs in this field are currently either in high school and have yet to decide if they will pursue a STEM degree, or are undergraduates who have no exposure to tribology in their standard engineering curriculum. This project aims to motivate students to pursue STEM degrees and then give them a unique advantage as they begin their careers by providing specialized skills in tribology. Merced is a Hispanic Serving Institution and a Minority Serving Institution, and its undergraduate students, as well as the predominantly Hispanic pre-college students from the Merced area, face many challenges. These students are the target audience of this instrumentation grant and our goal is to provide research and training to help to build the diverse research community and workforce that will be needed to tackle the critical scientific and technological challenges of the future.

Accomplishments: We purchased a Universal Tribometer from Rtec Instruments using all awarded funds. The instrument was delivered at the beginning of November 2016.

Most of the impact of this purchase has been through training of graduate and undergraduate students and dissemination to audiences ranging from middle school students to students at the local community college. However, there has also been research impact based on work the students have done with the new instrument. Our key research accomplishments are the following:

1. Our colleagues at the University of Maryland have developed a new method of processing wood to create super hard and hydrophobic structural materials. The UC Merced team performed a series of indent and scratch hardness experiments on various samples and in different directions to characterize these properties; see Figure 2. This research is reported in a paper that is currently under review: J Song, C Chen, S Zhu, M Zhu, J Dai, U Ray, Y Li, Y Kuang, Y Li, N Quispe, Y Yao, A Gong, UH Leiste, HA Bruck, JY Zhu, A Vellore, A Martini, T Li, L Hu, Super Strong and Tough Wood, Nature, Under Review.

2. Colleagues the University of Akron have applied ultrasonic nanocrystal surface modification (UNSM) to improve the surface properties of materials. We have collaborated with them to test the indent and scratch hardness of various UNSM-treated materials, include Mg, 3D printed surfaces, and a NiTi alloy; see Figure 3. This research is reported in a paper that is currently under review:
X Hou, S Mankoci, N Walters, H Gao, R Zhang, S Li, H Qin, Z Ren, GL Doll, H Cong, A Martini, VK Vasudevan, X

Zhou, N Sahai, Y Dong and C Ye, Hierarchical structures on Nickel-Titanium fabricated by a simple one-step Ultrasonic Nanocrystal Surface Modification, Materials Science & Engineering C, Under Review.

3. Novel polymeric lubricant additives have been developed and synthesized by our colleagues at Pacific Northwest National Lab. To test their performance, we performed a series of rotary sliding tests in the boundary lubrication regime to characterize friction and wear; see Figure 4. The findings showed that there is a correlation between polarity and performance, and also that these additives may be viable replacements for more toxic chemicals that are used in today's oil formulations. A paper describing these results is currently in preparation and we intend to submit by the end of this month: L Cosimbescu, A Vellore, US Ramasamy and A Martini, Low Molecular Weight Polymers as Friction Modifiers, RSC Advances, Under Review.

Training Opportunities: Initial training on the instrument was provided by the company to the PI and her graduate student Azhar Vellore. Since then, six undergraduates and one additional graduate student have been trained on its use. The undergraduates include students from both UC Merced and the local community college, Merced College. In addition to the instrument-specific training, the PI provides all students with more general training related to the fields of tribology and surface characterization. A picture of the PI and some of these students with the instrument is provided as Figure 1 of the uploaded document. Also, in the spring semester of 2017, the tribometer was made available to the students in the UC Merced capstone design course. This course includes all graduating seniors across the engineering majors; last semester there were 20 interdisciplinary teams of students working on a variety of project. Several of these teams either explored the capabilities of the instrument or performed measurements using it as part of their projects.

Results Dissemination: In June 2017, the PI invited a class of 8th graders from a middle school in nearby Modesto CA to tour the lab. We are currently fine-tuning our lab tour demo and plan to continue providing these tours to local elementary, middle and high school students.

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: We have had multiple discussions with Dr. Michael Dugger at Sandia National Lab about both potential collaboration and also the best way to train our undergraduate students so they are prepared to contribute through internship opportunities at the Lab. One such discussion was held in person in Albuquerque NM in May 2017. Also, although not directly related to this instrument grant, we have been collaborating with Dr. Stephen Berkebile on research whose goal is to understand the basic interfacial chemical reactions between ferrous surfaces and organophosphate molecules and their dependence on critical parameters found in technologically relevant contacts. We have monthly conference calls to discuss the project and met in person in April 2017 at the American Chemical Society spring meeting. We are currently finalizing a paper reporting the outcomes of the collaboration so far and are targeting later this month for submission.

PARTICIPANTS:

Participant Type: PD/PI
Participant: Ashlie Martini
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Azhar Vellore
Person Months Worked: 12.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:

National Academy Member: N
Other Collaborators:

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Participant: Uma Ramasamy
Person Months Worked: 3.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Undergraduate Student
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Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
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National Academy Member: N
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National Academy Member: N
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Project Contribution:
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Other Collaborators:

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Project Contribution:
International Collaboration:
International Travel:
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Other Collaborators:

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Tribology-Based Research and Training for Underrepresented Minorities

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Figure 1: Photo of the PI with the new Rtec Universal Tribometer along with the undergraduate and graduate students working on the tribometer in this summer. From left to right: Standing – Salvatore Angrisani (Senior), Adam DeLong (Sophomore), Kimberly Rodriguez (Junior), Azhar Vellore (PhD student); Kneeling – Michael Walker (Sophomore), Ashlie Martini, Uma Ramasamy (PhD student graduating in August 2017).

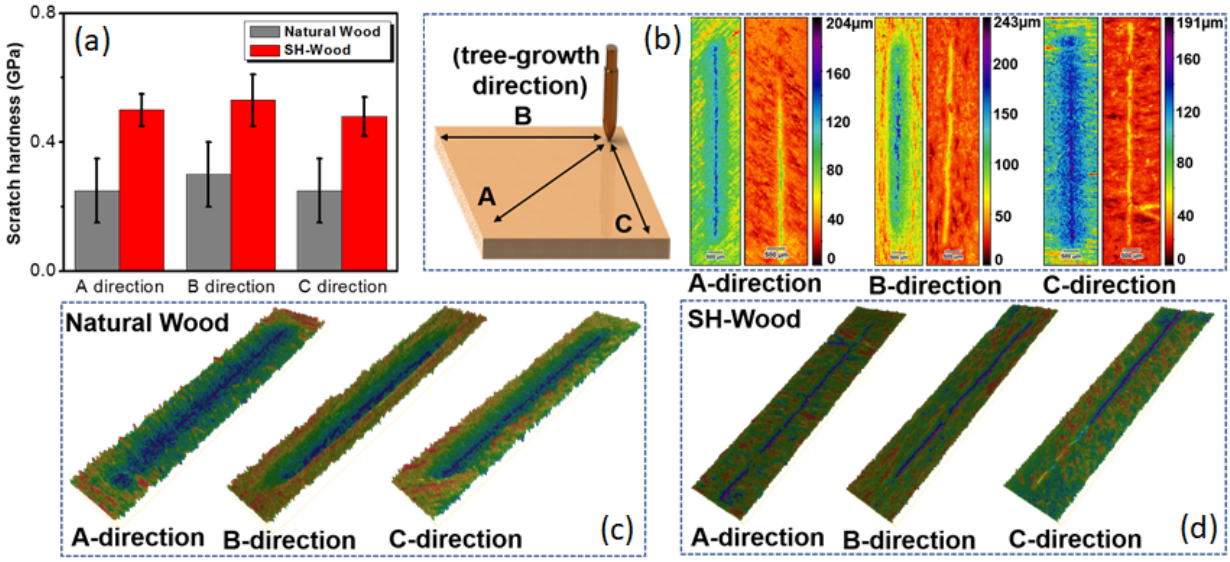

Figure 2: Measurements of scratch hardness using the new instrument of wood treated using a novel process to make it super hard. (a) Scratch hardness of natural wood and super hard wood in three directions (A, B and C directions). (b) Schematic illustration of the scratch hardness measurement along the three directions and interferometer images of representative scratches on the natural wood (left) and super hard wood (right) along the A, B and C directions, showing the significant decrease of the scratch depth on the super hard wood due to increasing the hardness along all three directions. (c and d) Topography images of natural wood and super hard wood along the A, B and C directions.

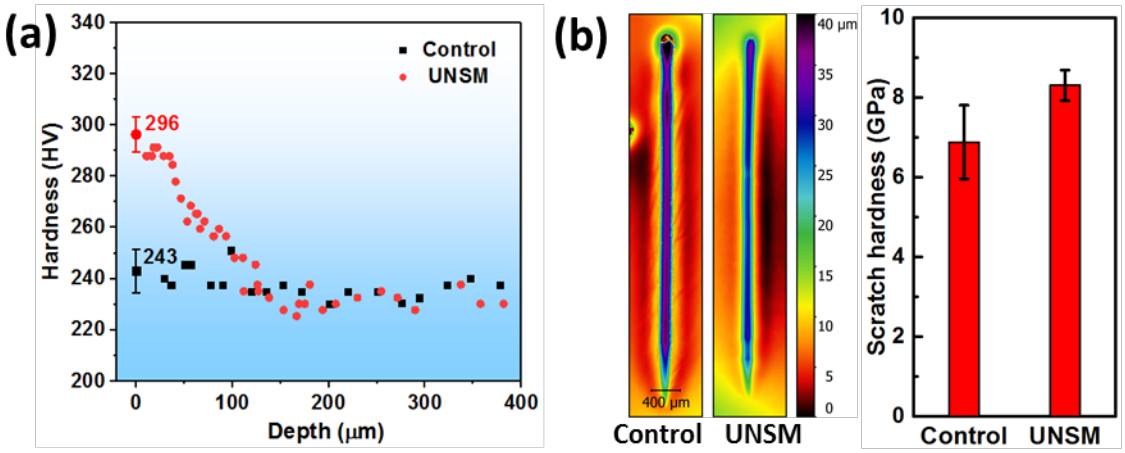

Figure 3: (a) Hardness depth profile of NiTi with and without ultrasonic nanocrystal surface modification (UNSM). (b) Interferometer images of surfaces after scratch hardness testing on NiTi with and without UNSM (left) and average scratch hardness measurements (right). Measurements taken using the new instrument at UC Merced.

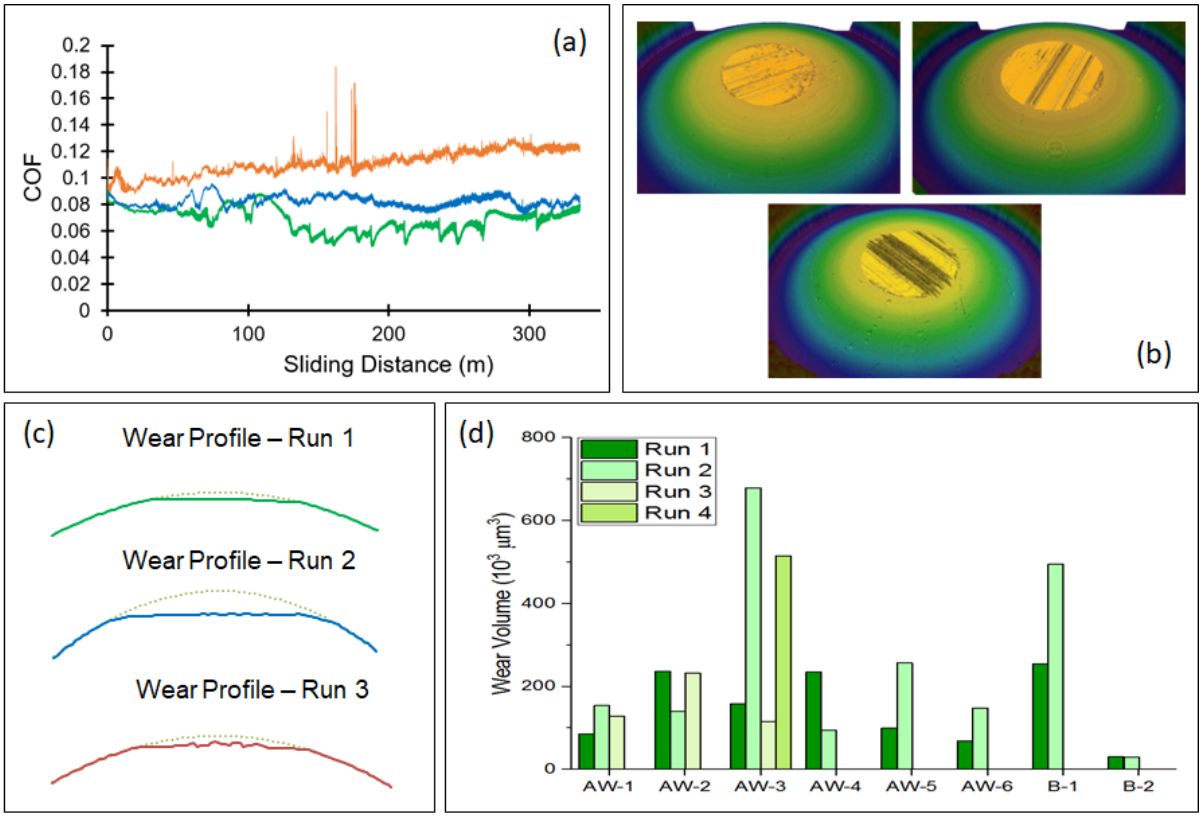

Figure 4: Studies of the effect of lubricant additives performed at UC Merced using the new instrument. (a) Representative friction traces from measurements of boundary lubricated sliding with a novel polymeric additive. (b) Interferometer images of the ball after testing used to calculate wear. (c) 2D profile of the ball before and after sliding; the difference between these is the wear volume. (d) Wear volume measured for various novel polymeric additives (AW-1 to AW-6) and two benchmark additives (B-1 and B-2).